A Fully Redundant On-Line Mass Spectrometer System Used to Monitor Cryogenic Fuel Leaks on The Space Shuttle

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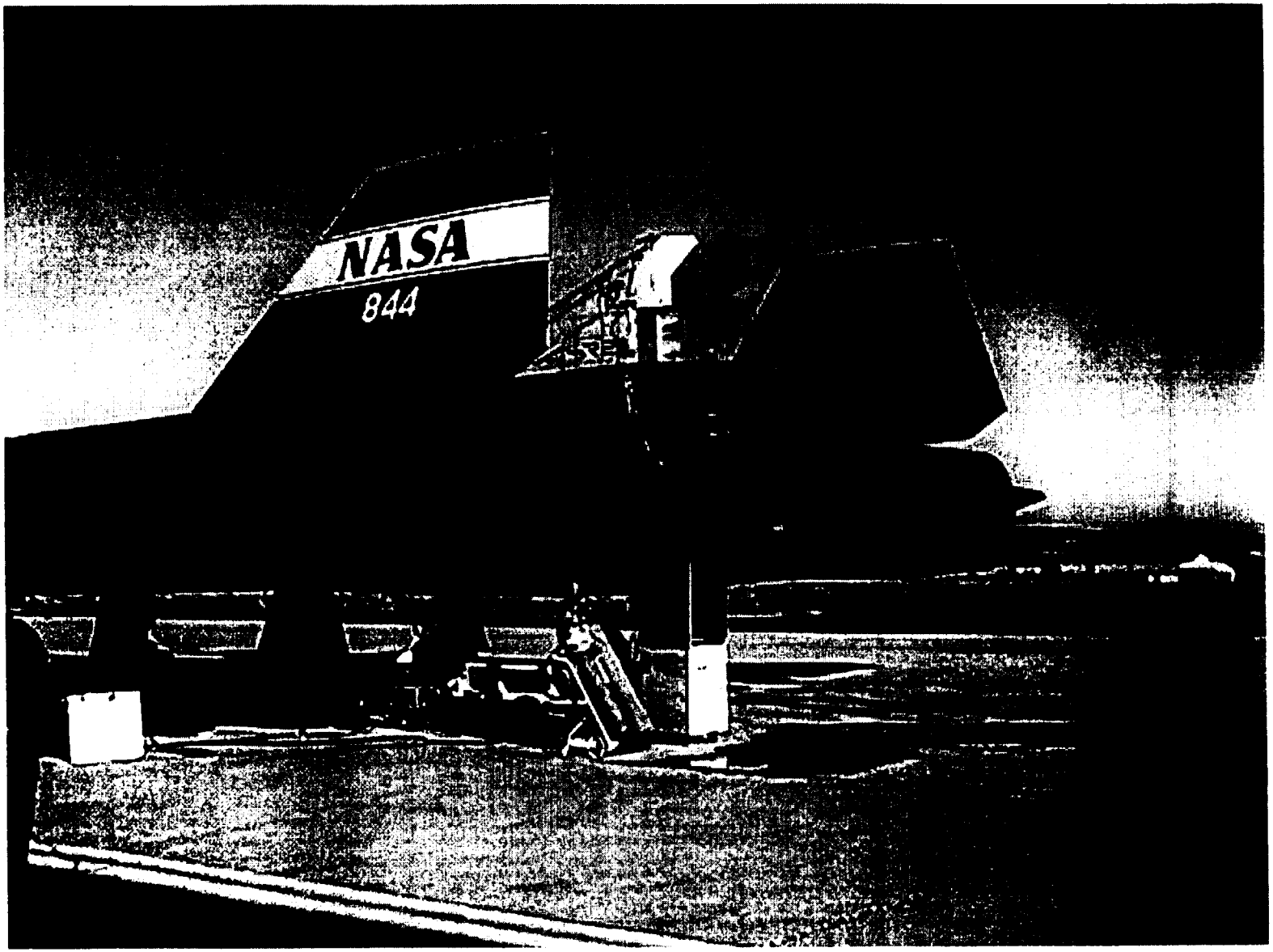
Hazardous Gas Detection Lab

- Design and build mass spectrometer based process systems used to monitor for cryogenic leaks
- Systems used with Shuttle, LASRE, and X-33
- Currently tasked by NASA to develop next generation system
- Develop on-line air monitor systems for use in Shuttle and Space Station
- KSC on-center R&D contract

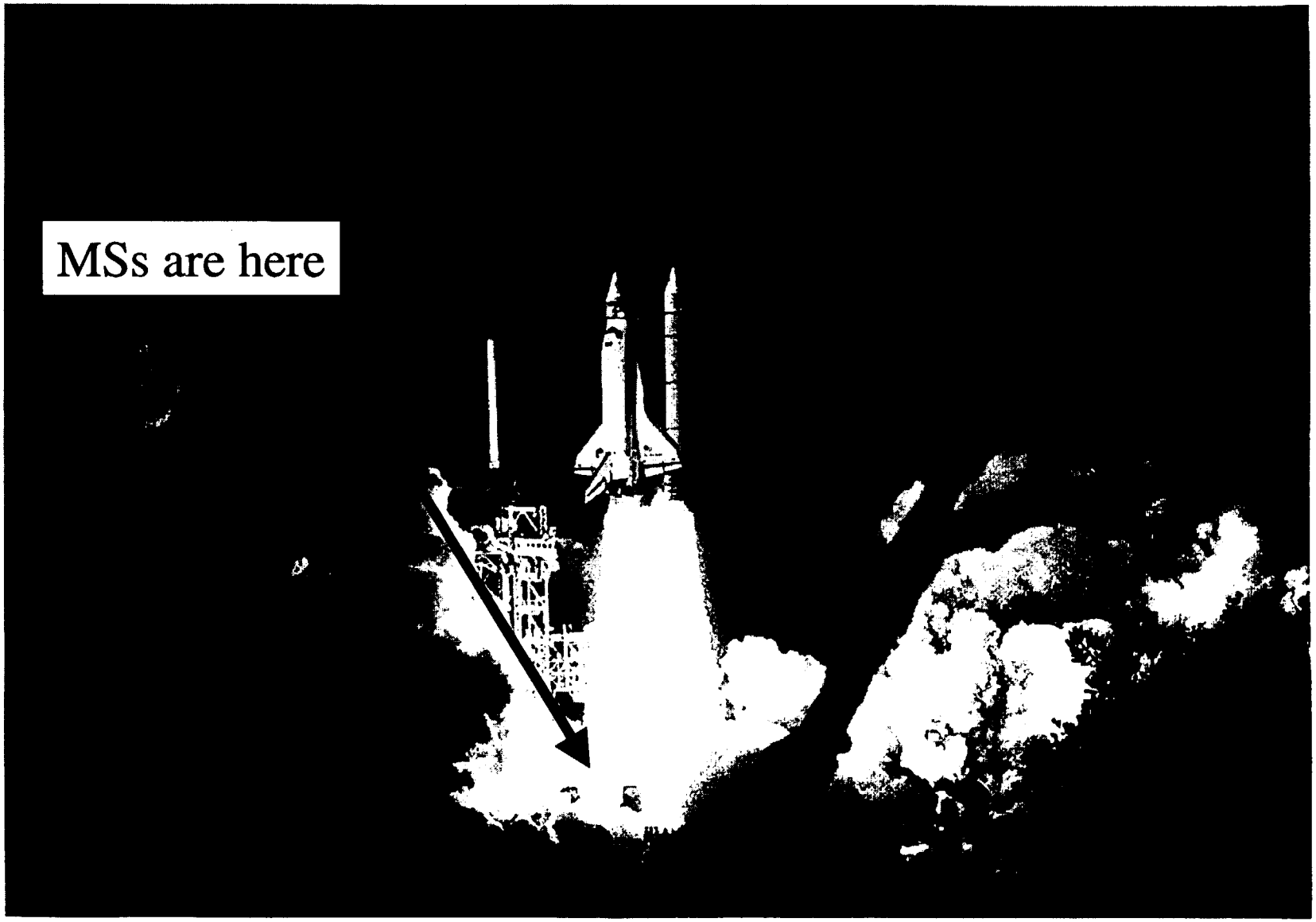
LASRE Test Support



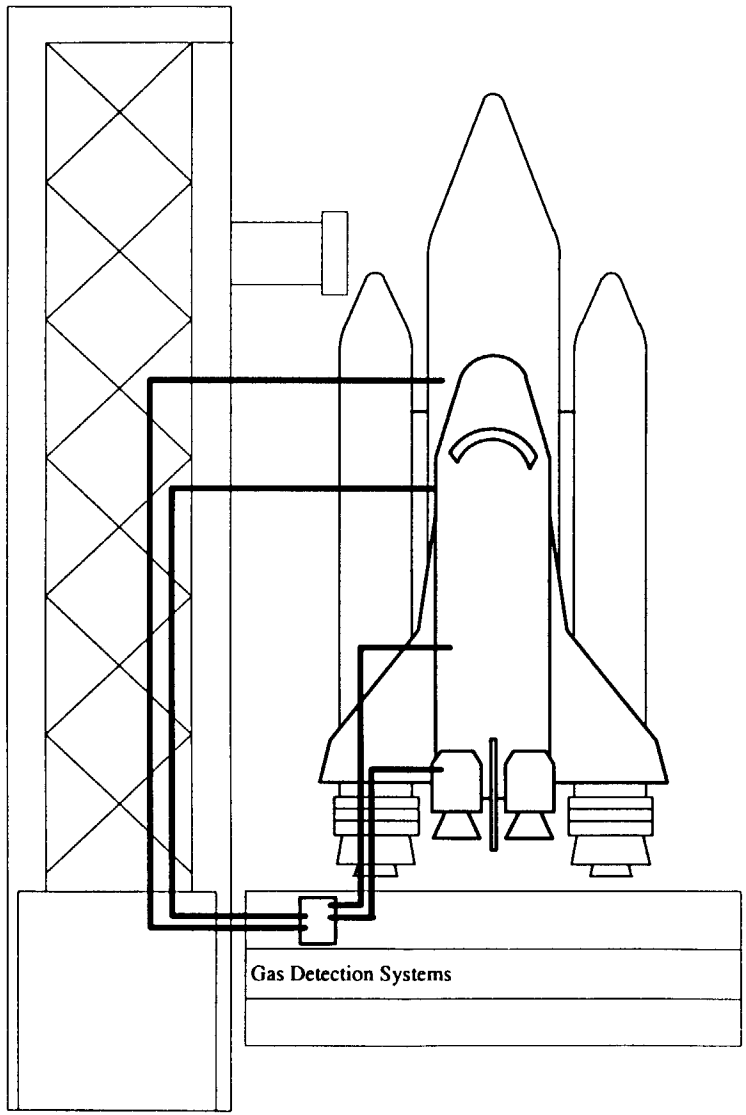
Background

- Mass spectrometer systems have been in use since the beginning of the Space Shuttle Program
- Four systems currently in use: Prime, Backup, HUMS, and PAMS
- Monitor in N_2 background - H_2, He, O_2, and Ar
- Monitor in He background - H_2, N_2, O_2, and Ar
- New prototype in use – HGDS 2000
- All systems have MS removed (up to 300 feet) from sample location

Location of Systems



Sample Lines for Gas Detection



Problems with Current Systems

- Remote location of MS
- Delay of 15 to 20 sec before detecting leak
- Cannot monitor last 20 sec of launch data
- Only monitor in a round-robin method
- Large, expensive system
- Cannot monitor more than a few locations

Requirements for New System (Nitrogen Background)

	H2	He	N2	O2	Ar
Limit of Detection	25	100	N/A	25	10
Response Time (sec)	<10	<10	<10	<10	<10
Recovery Time (sec)	<30	<30	<30	<30	<30
He -> N2 Background (sec)	<60	<60	<60	<60	<60
Drift Background Gas(ppm) 12 hrs	30	30	<100,000	30	<6
Drift Medium Conc Gas (%) 12 hrs	<16	<16	N/A	<16	<15
Accuracy/Precision (%)	<10	<10	< 10 %	<10	<10
Low Level He Detection Limit (ppm)		<5			
Low Leve He Drift	< 5 % in 2 Hours				

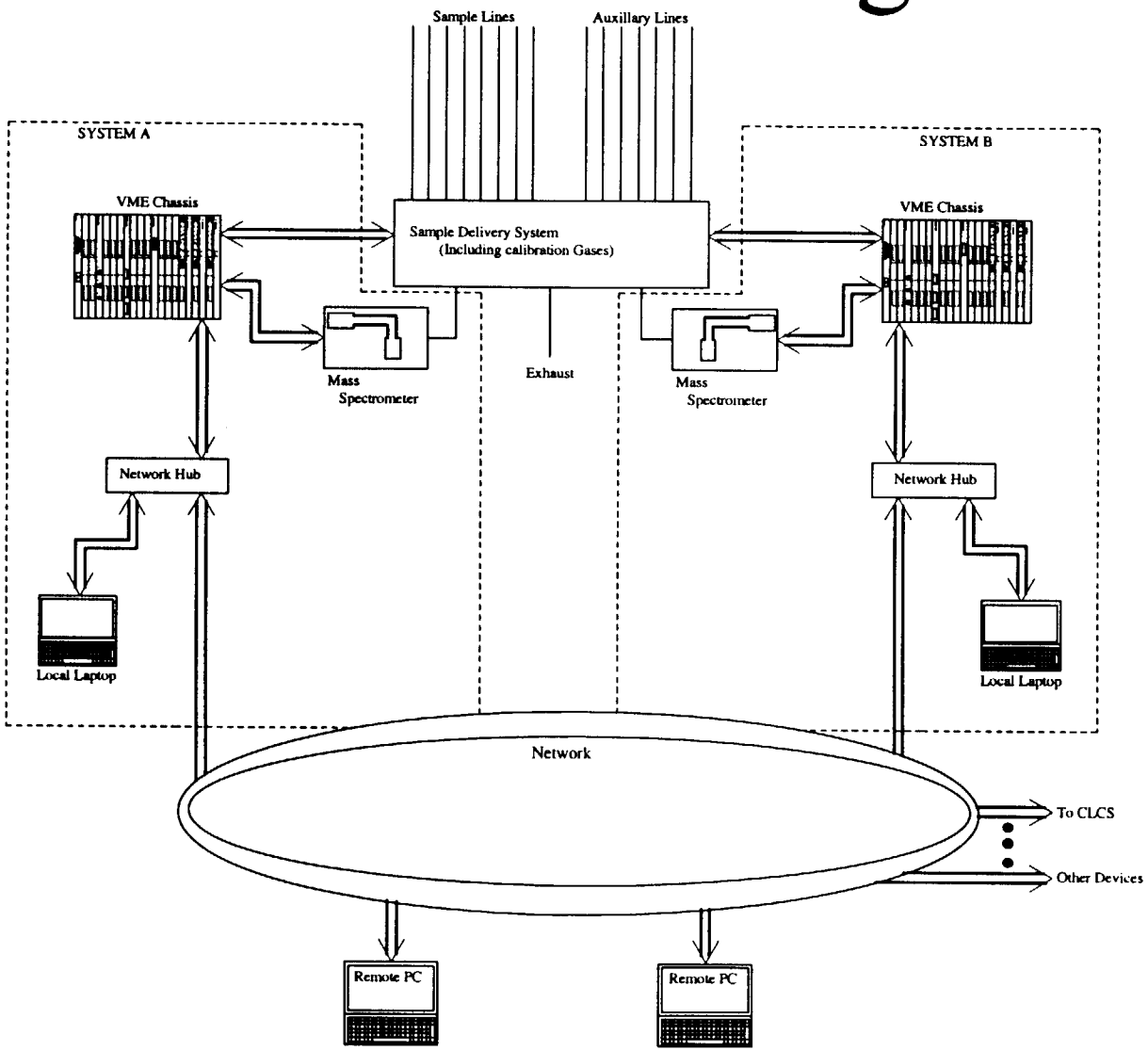
Requirements for New System (Helium Background)

	H2	He	N2	O2	Ar
Limit of Detection	1000	N/A	1000	1000	50
Response Time (sec)	<10	<10	<10	<10	<10
Recovery Time (sec)	<30	<30	<30	<30	<30
He -> N2 Background (sec)	<60	<60	<60	<60	<60
Drift Background Gas(ppm) 12 hrs	<300	<100,000	<300	<300	<300
Drift Medium Conc Gas (%) 12 hrs	<15	N/A	<15	<15	<15
Accuracy/Precision (%)	<10	<10	<10	<10	<10

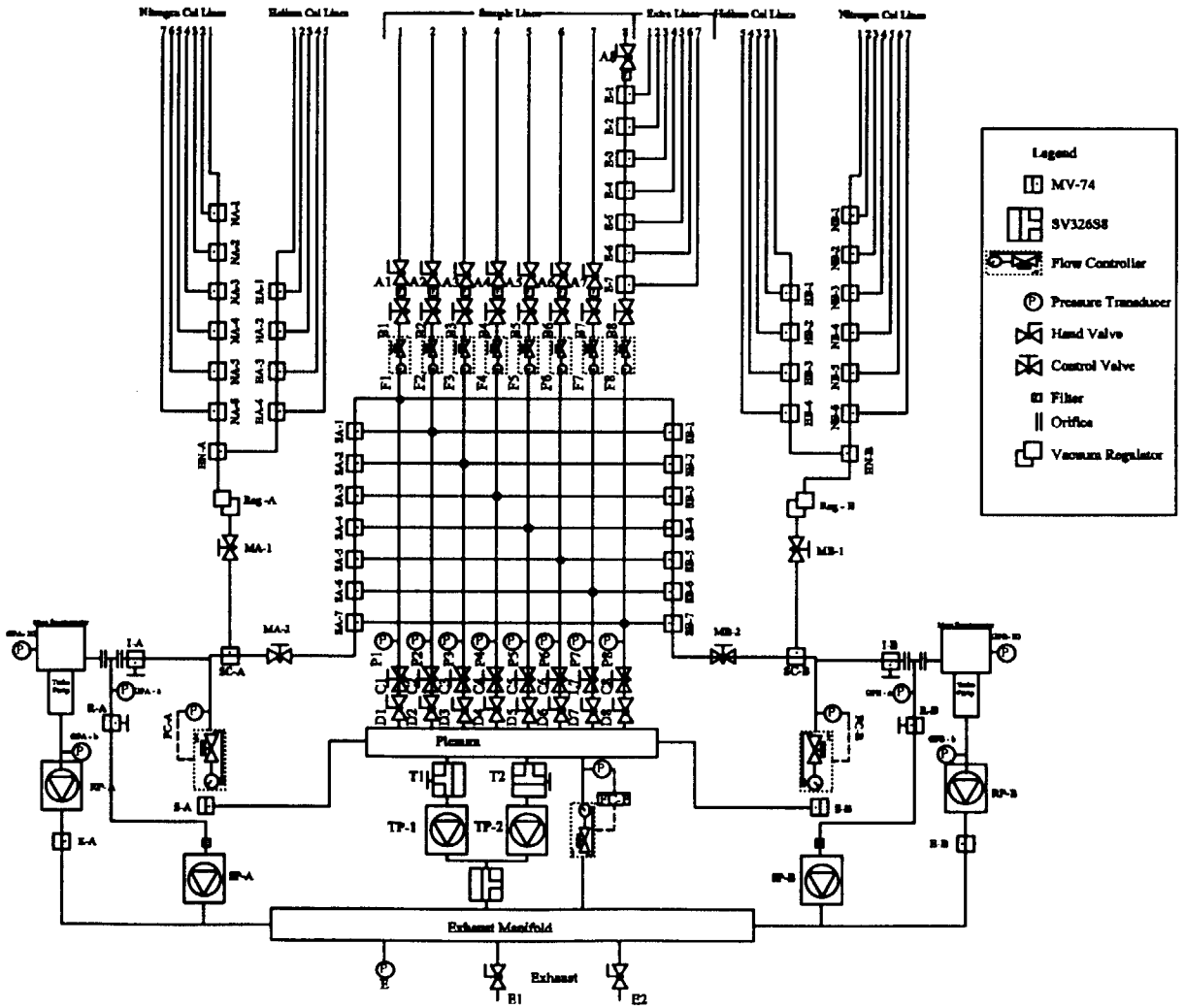
HGDS 2000

- Sample lines are continuously pumped
- Fully redundant system
- Two single-quadrupoles (Stanford Research Systems)
- High vacuum and inlet designed/built in-house at KSC

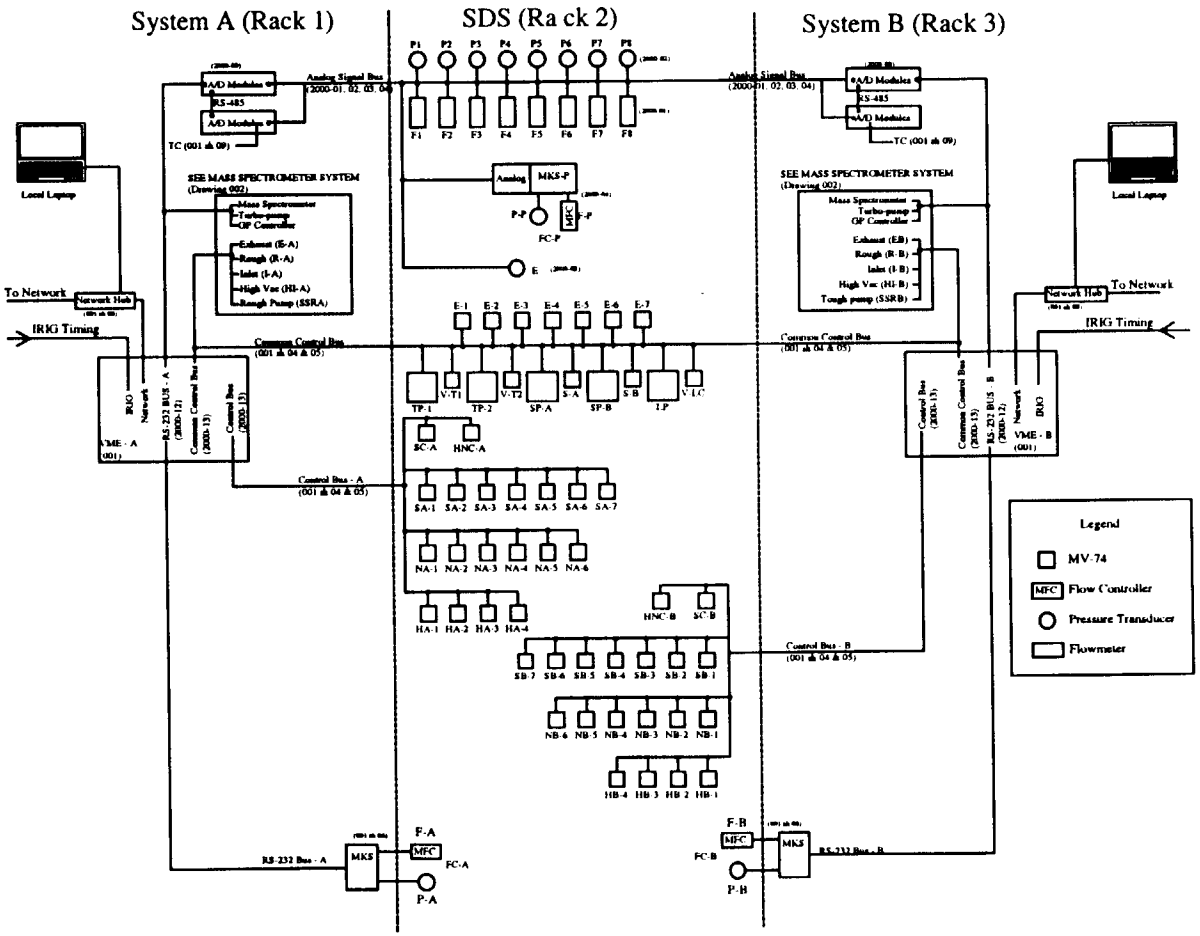
HGDS 2000 Diagram



HGDS 2000 Pneumatic



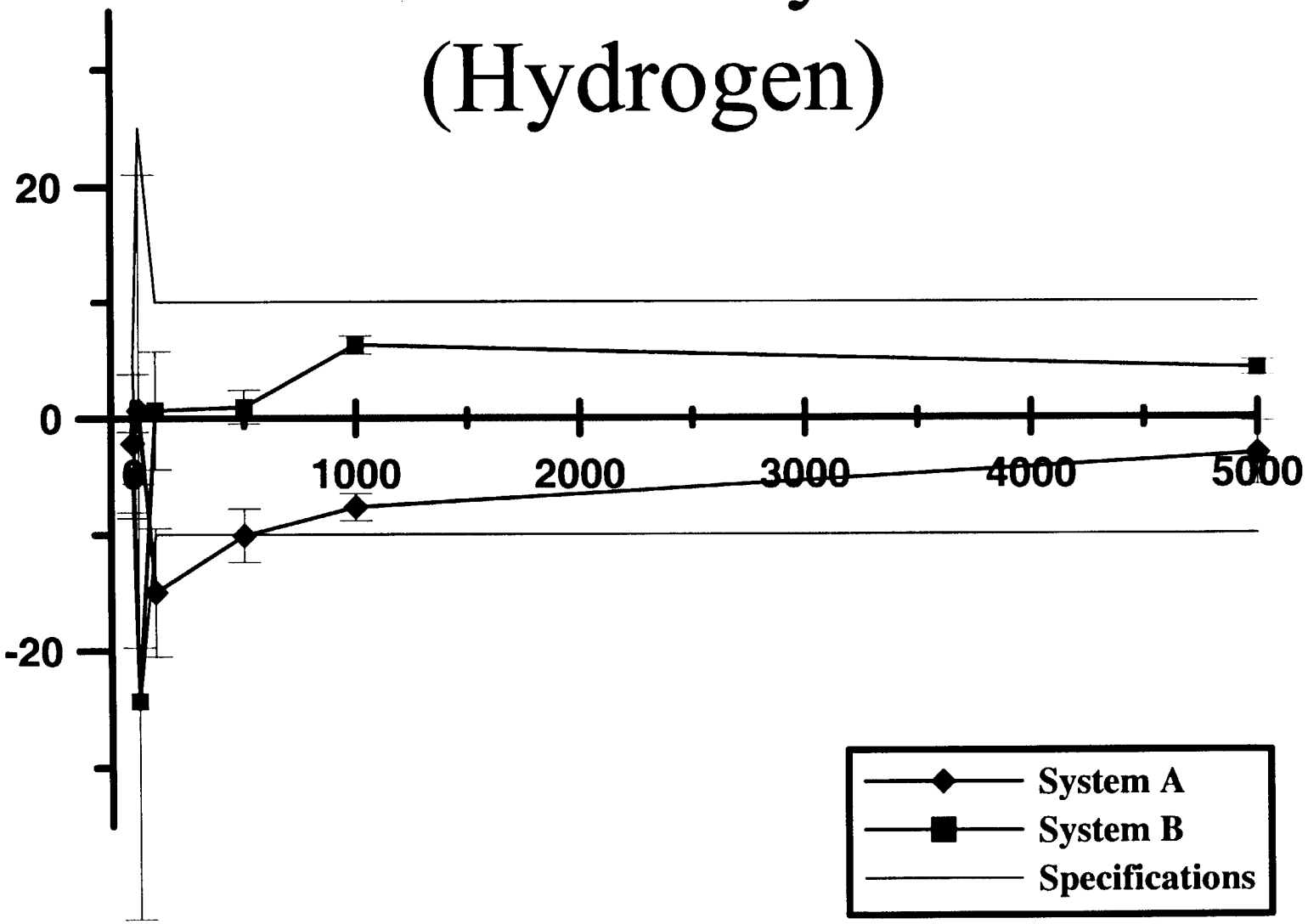
HGDS 2000 Electrical



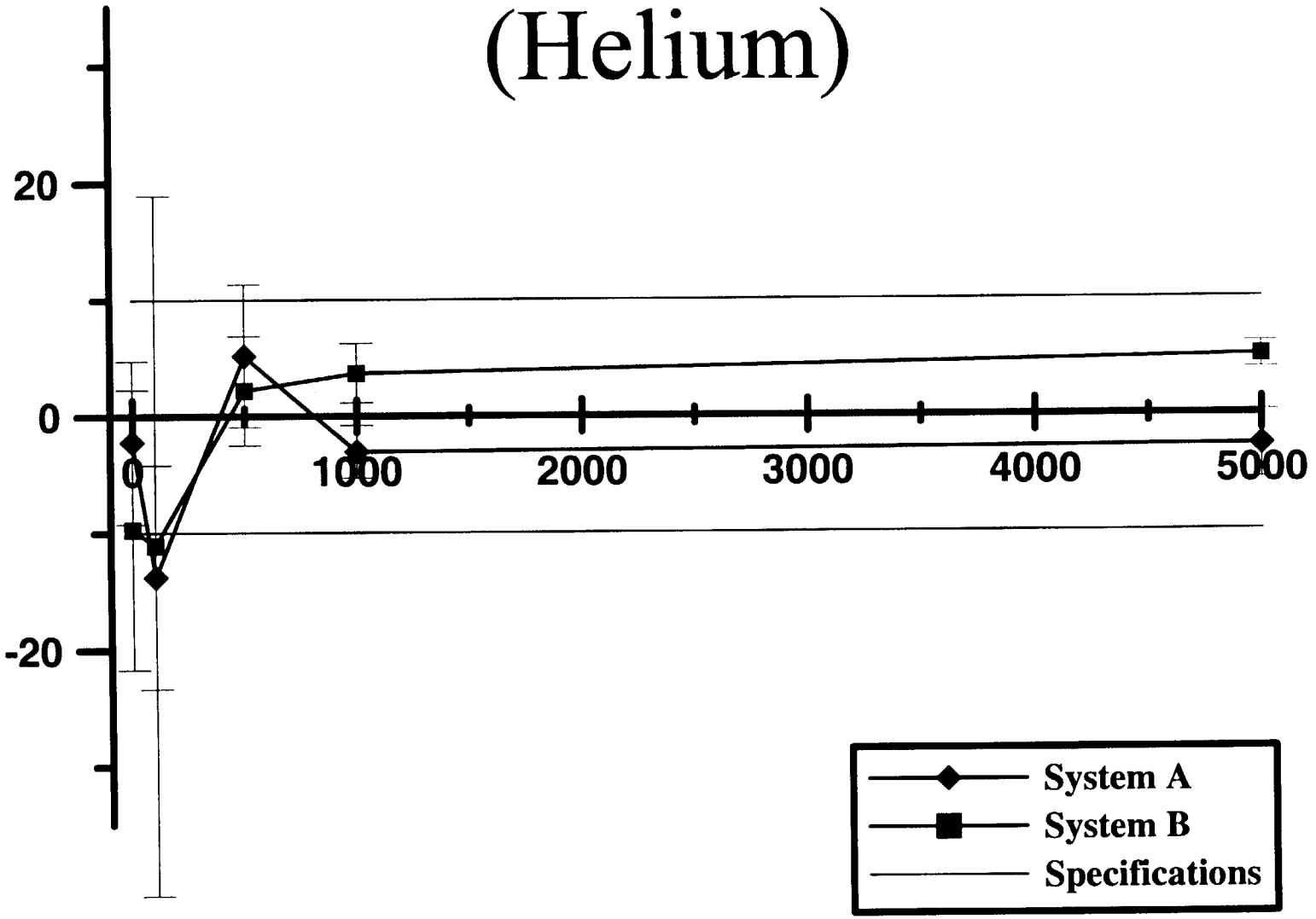
HGDS 2000 Results

- Response time (from leak location) – 15 to 20 sec
- LOD - < 25 ppm H_2, He, O_2, and Ar
- Drift - < 30 ppm in 12 hours
- Remote and local operation
- MS response 5 sec (0 to 5000 ppm)
- MS background change He -> N_2 < 1.5 min

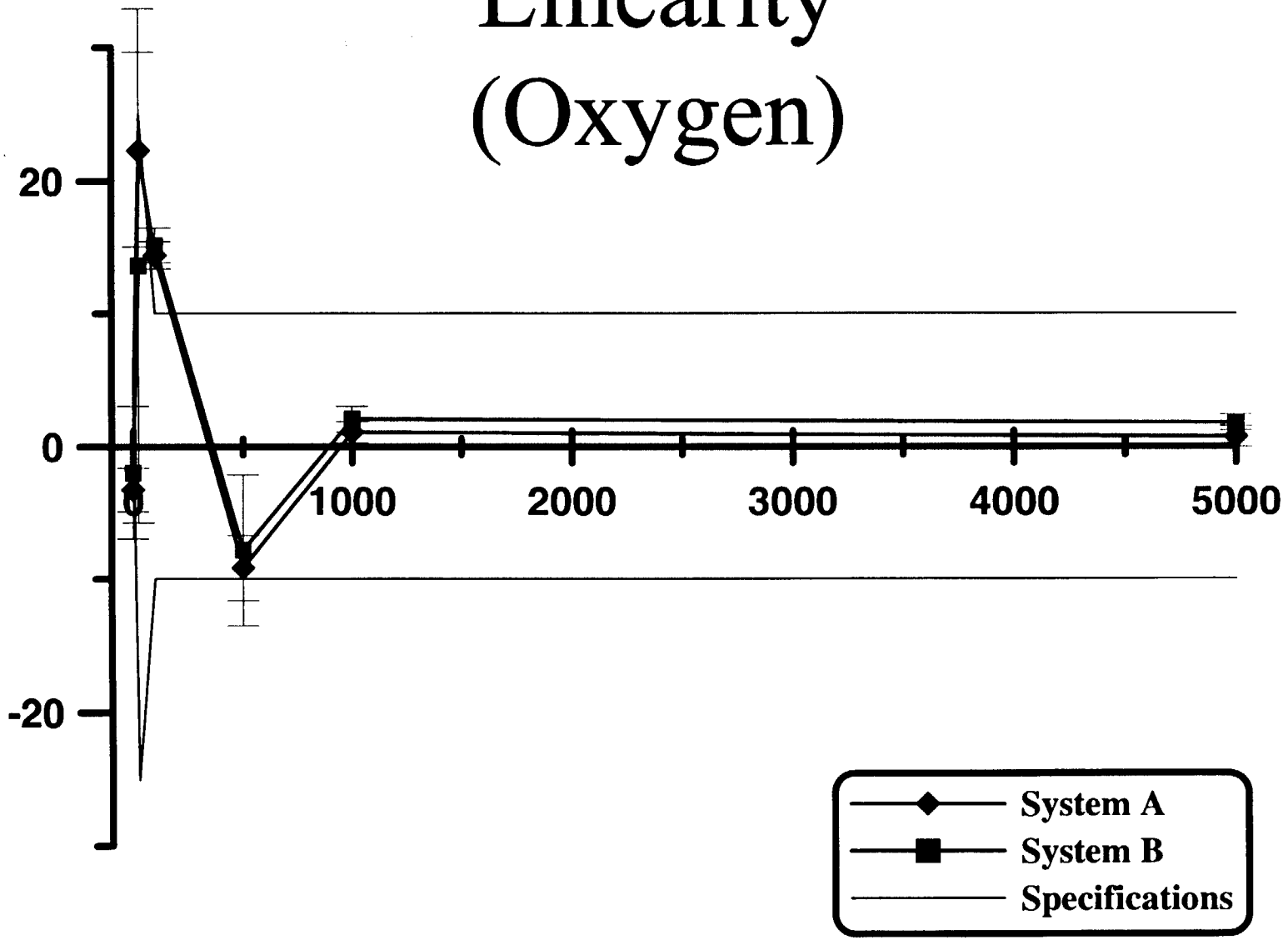
Linearity (Hydrogen)



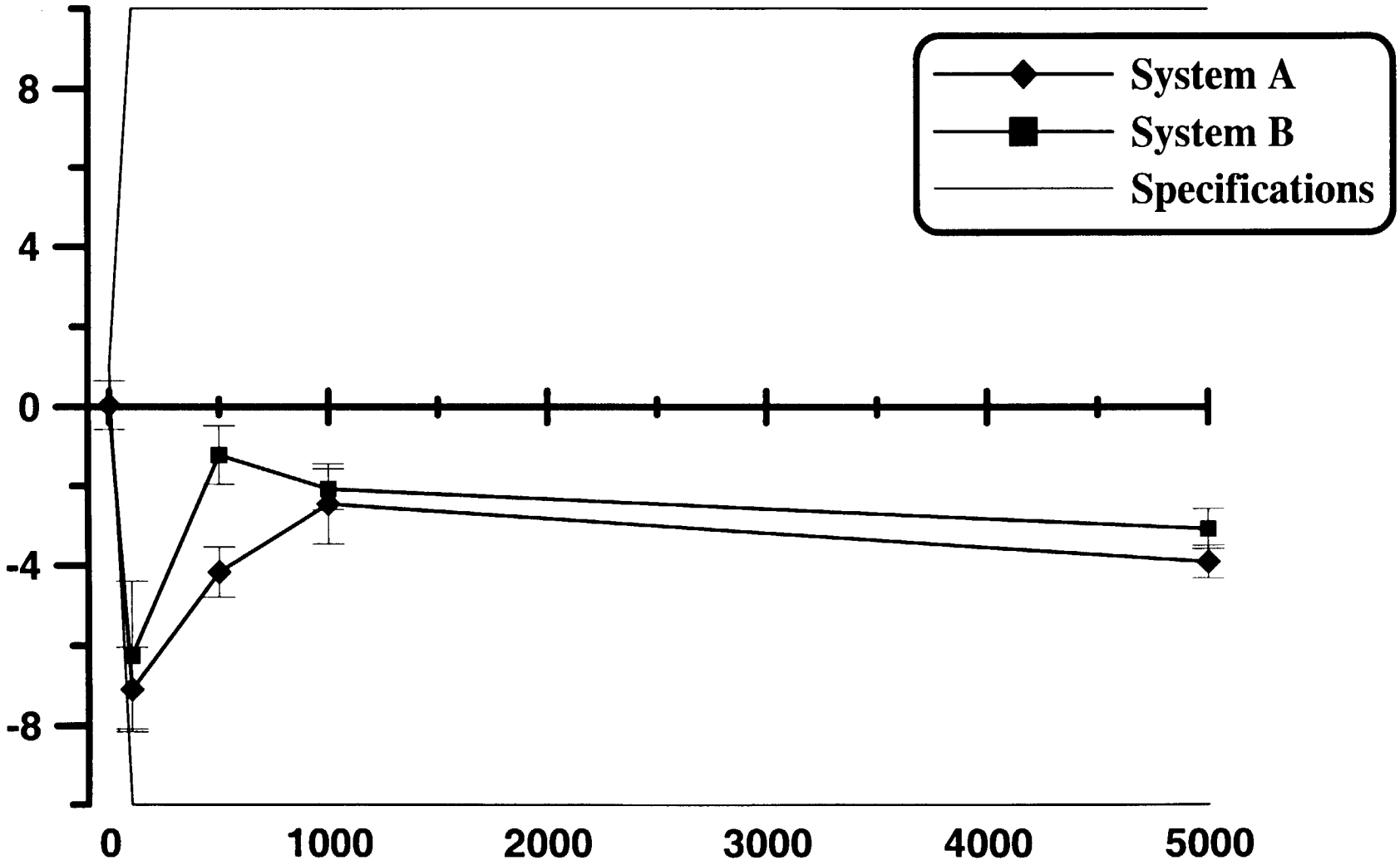
Linearity (Helium)



Linearity (Oxygen)



Linearity
(Argon)



Future Work

- Small, rugged systems
- Multiple MS's throughout Orbiter
- Fully autonomous
- Faster response/recovery times
- Faster update rates
- Smaller, more robust PUMPS